

2015

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Nobusuke Iwasaki

*National Agriculture and Food Research Institute, Institute*

David Spraguea

*National Agriculture and Food Research Institute, Japan*

Naoko Fujita

*Faculty of Design, Kyushu University*

Ikuhiro Teramoto

*Western Region Agricultural Research Center, National Agriculture and Food Research Organization*

Hiroshi Yamaguchi

*Art Research Center, Ritsumeikan University*

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### Recommended Citation

Iwasaki, Nobusuke; Spraguea, David; Fujita, Naoko; Teramoto, Ikuhiro; and Yamaguchi, Hiroshi (2015) "Developing a land use database of the Kanto Region, Japan in the 1880's," *Free and Open Source Software for Geospatial (FOSS4G) Conference Proceedings*: Vol. 15 , Article 41.

DOI: <https://doi.org/10.7275/R5FT8J83>

Available at: <https://scholarworks.umass.edu/foss4g/vol15/iss1/41>

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## Developing a land use database of the Kanto Region, Japan in the 1880's

**Nobusuke Iwasaki<sup>1</sup>, David S. Sprague<sup>1</sup>, Naoko Fujita<sup>2</sup>,  
Ikuhiro Teramoto<sup>3</sup> and Hiroshi Yamaguchi<sup>4</sup>**

<sup>1</sup>Ecosystem Informatics Division, National Institute for Agro-Environmental Sciences  
3-1-3 Kannondai, Tsukuba 305-0031, Japan  
Email: niwasaki@affrc.go.jp, sprague@affrc.go.jp

<sup>2</sup>Faculty of Design, Kyushu University  
4-9-1 Shiobaru, Minami-ku, Fukuoka 815-8540, Japan  
Email: fujita@design.kyushu-u.ac.jp

<sup>3</sup>Western Region Agricultural Research Center, National Agriculture and Food Research Organization  
6-12-1 Nishifukatsu-cho, Fukuyama 721-8514, Japan  
Email: yellow@affrc.go.jp

<sup>4</sup>Art Research Center, Ritsumeikan University  
56-1 Toujiinn-kitamachi, Kita-ku, Kyoto 603-8577, Japan  
Email: yamahirog@gmail.com

### ABSTRACT

*Historical land use records are valuable information for biodiversity protection, disaster management, rural area planning and many other uses. The Rapid Survey Maps (RSM) that were surveyed in the 1880's (early Meiji Era), are the first modern cartographical map series of Japan and important sources of information on traditional land use in early modern Japan. We had been analyzing these maps based on polygon data and raster based Web-GIS System to disseminate the Rapid Survey Maps using FOSS4G, but, these are difficult to apply for quantitative analyses of land use change. Thus, we developed a grid based land use database using QGIS and PostGIS, and published the database using GitHub.*

*First, we developed a land use data input system consisting of a client and server. The client was developed using QGIS API and the server was a PostGIS database. Point data as a 100 m grid was stored in the PostGIS server and land use category underneath each point was input using the QGIS application. About 1,400 thousand records (70%) have already been inputted. Error of grid based land use data is less than 1% compared with vector based land use data.*

*We analyzed land use change from the 1880's to 1975's. The most significant difference between the 1880's and 1970's is the area of urban land use and "rough land" such as grassland and bush. Urban area increased remarkably and grassland area almost disappeared. That does not mean grassland changed to urban area. Most grassland changed to agricultural land uses and forest, and urban area was formerly mainly agricultural land use and forest.*

*Some inputted data have been copied to GeoJSON and uploaded to GitHub as open data (Creative Commons BY 2.1 Japan). A tentative data browsing site was constructed with Leaflet. In this site, it is possible to compare point type land use data in the 1880's and present topographic map/RSM raster data. We hope that this database contributes to not only academic research, but also business, government, and public interest.*

## 1. INTRODUCTION

Historical land use records are valuable information for biodiversity protection, disaster management, rural area planning and many other uses. For these purposes, accurate survey maps are necessary. In the case of Japan, because the national isolation policy continued until the end of the Edo era, there was not accurate map until the 1880's. At this time, the Japanese government didn't have national mapping agency. Thus, the regional divisions of the Japanese army surveyed

their own territory. The method of survey was called the Rapid Survey Maps Methods (*Jinsoku-sokuzu-hou*) and the maps which were surveyed by these methods, were called the Rapid Survey Maps (*Jinsoku-sokuzu*). In the Kanto region, around Tokyo, the Rapid Survey Maps (RSM) that were surveyed in early Meiji Era, are the first modern cartographic map series of Japan. The survey extent of the RMS is show show in Figure 1. The most of the Kanto plain and the Boso peninsula were included survey extent.

**Figure 1. Coverage of Rapid Survey Maps.**

**Figure 2. Image of Rapid Survey Map.**

Figure 2. shows an image of a topical RSM. The land use categories were delineated by color with Chinese characters marking land use. In some RSM, there was a scenery picture outside of map extent. The pictures are also important sources for reconstructing the land use and landscape in early modern Japan.

The RMS is important sources of information on traditional land use in early modern Japan. There are many studies about the RSM and land use in early Meiji era. Shirai (2002) analyzed land use in the Shimousa plateau. Ichikawa (2006) described transition of the satoyama landscape in the west part of Tokyo. Sprague and Iwasaki (2009) were conducted time serise analysis of land use change in southern Ibaraki prefecture. Koyanagi *et al.* (2012) evaluated impacts of past landscape on present distribution of species in the Inashiki plateau. Iwasaki and Sprague (2005) examined the relationship between land use change and habitat of Japanese macque in the Boso peninsula. But it is difficult to view land use for entire Kanto plain. Therefore, we developed Web-GIS system (Historical Agro-Environmet Browsing System, HABS) for disseminating RSM data using FOSS4G (Iwasaki *et al.*, 2009). After the release of HABS, many people used RSM data not only for academic purpose, such as biodiversity conservation and disaster management, but also for hobby use, for example, exploring old pilgrimage path, abandoned roads and castle ruins of old castles. However, it is still difficult to apply quantitative analyses of land use change.

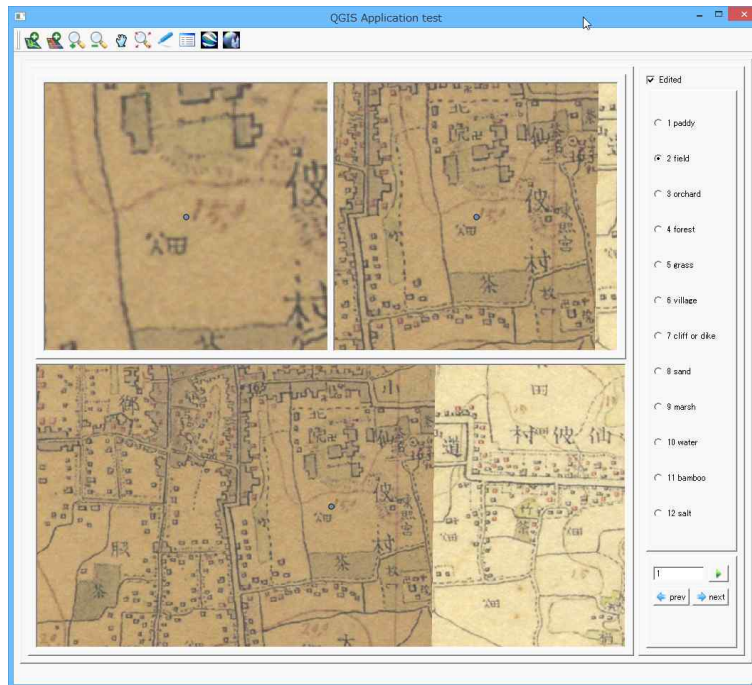
Thus, a purpose of this paper is developing a quantifiable land use database and publish the database as open data.

## **2. LAND USE INPUT SYSTEM AND ACCURACY ASSESSMENT**

### **2.1 Development of land use data input system**

First, we examined a data model of land use data. In a previous study, we developed polygon-based land use data (Sprague *et al.*, 2007, Sprague and Iwasaki, 2009). But, constructing polygon data is required intensive work. In the case of the RSM, digitizing required a month per map. A few decades may be necessary for inputting the polygon data of all RSM, because total number of RMS is about 900 maps. In this research, we input land use data as 100m grid point data.

We developed a land use data input system consisting of a client and server. The client was developed using QGIS API and the server was a PostGIS database. Point data as a 100 m grid was stored in the PostGIS server and land use category underneath each point was input using the QGIS application. This application makes inputting land use data easier and faster than polygon based methods.



**Figure 3. Land use input application developed by QGIS API.**

## 2.2 Accuracy assessment of point based land use data.

The point sampling method did not illustrate an actual land use in RSM. Thus, an accuracy assessment was conducted based on the comparison between polygon data and point data. In the assessment, we compared the land use category ratio of point and polygon data in the Ushiku area, southern part of Ibaraki Prefecture. The details of the area was described in Sprague and Iwasaki. (2009).

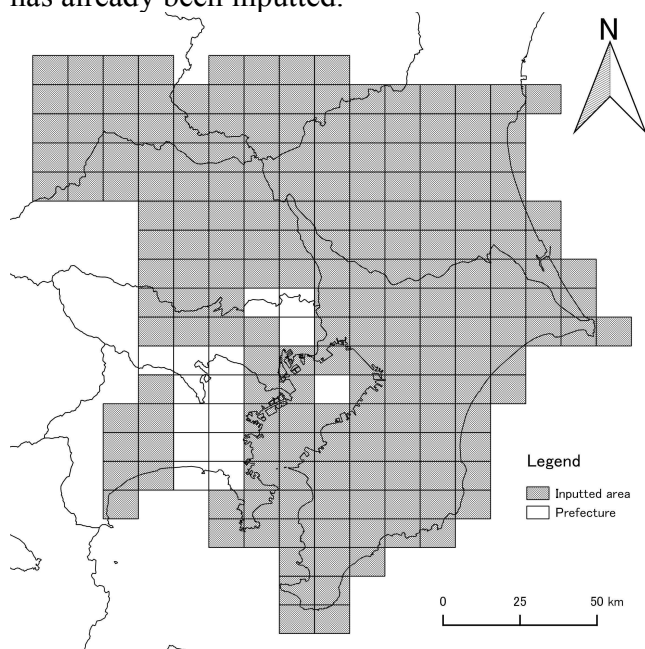
**Table 1. Land use ratio of point data and polygon data**

Land use	Area (%)	
	Point based data	Polygon based data
Paddy	14.17	13.56
Upland field	18.39	19.11
Tea, orchard	0.14	0.00
Wood	40.11	40.24
Grass, bush	18.64	18.46
Village, road	2.80	2.59
Marsh	0.77	1.02
Water	4.99	5.00

Table 1 shows the results of comparison. Relatively large error was observed in linear land use features, such as paddy field. But error of grid based land use data is less than 1% compared with vector based land use data and overall accuracy was enough to evaluate the long term land use change.

### 3. PROGRESS OF DATABASE DEVELOPMENT AND APPLICATION FOR LAND USE CHANGE EVALUATION

The total number of points in the RSM database is about 2 million and it is too much to operate at once. Thus, the point data were divided based on Japanese topography map grids (about 9 km north-south, 14 km east-west) and we inputted land use data by the map grid. Figure 4 shows the current progress of data input. About 90% of map grids, which showed gray color in Figure 4, has already been inputted.



**Figure 4. Progress of land use data input**

We analyzed land use change from the 1880's to 1975's using the east part of inputted data. The land use data in the 1975's was obtained from the "National Land Numerical Information Land utilization segmented mesh Data". The segmented mesh is a grid type data and size of grid is about 100 by 100 m.

The land use in the 1880's are thought to represent a traditional rural land use pattern in Japan. And the land use in the 1975's might be under the strong influence of high economic growth in Japan. Therefore, land use change from the 1880's to 1975's might reflect Japanese rapid modernization and economical growth.

The table 2 shows land use in the 1880's and 1975's. The most significant difference between the 1880's and 1975's is the area of urban land use and "rough land" such as grassland and bush. Urban area increased remarkably from 7.3% to 13.4%. On the other hands, grassland area decreased significantly from 11.1% to 1.1%. The area of increased urban land use and decreased grassland were similar value. The area of forest and upland fields don't show large change. But that does not mean grassland changed into urban land use and forest and upland field were stable.

**Table 2. Land use in 1880's and 1970's**

	Area (%)	
Land use	1880's	1975's

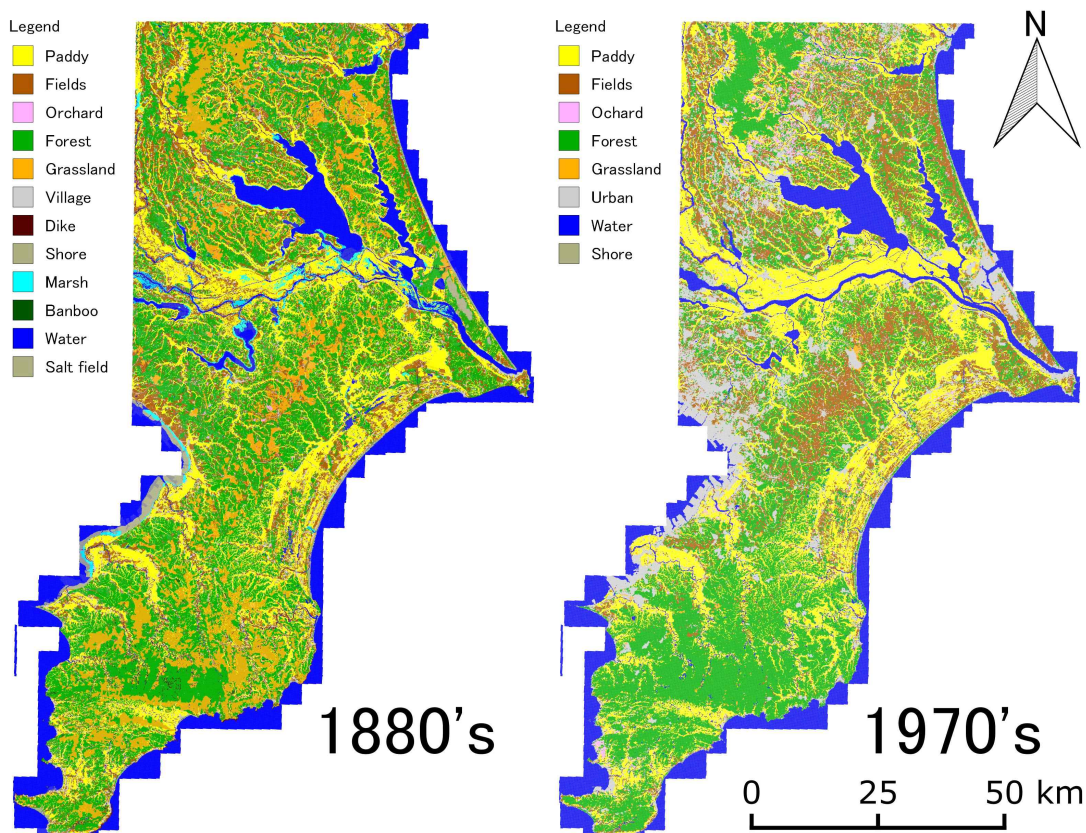
Paddy	19.4	23.7
Upland field, orchard	13.5	17.4
Wood	31.7	30.4
Grass, bush	11.1	1.1
Village, urban	7.3	13.4
Water, mash	17.0	14.6

Table 3 is land use change matrix between two times and Figure 5 is land use maps in the 1880's and 1975's. About 60% of grassland in 1880's changed to forest and 22% became to upland fields. In 1880's grassland mainly occupied hill slope and plateau. Grassland on the hill slope and plateau was converted to forest and upland fields, respectably. Regarding urban land use, 16.6% of upland fields and 12.6% of forest in 1880's changed to urban land use in 1975's. We can concluded that there were complex land use change pattern in the Kanto region.

**Table 3. Land use change matrix from 1880's to 1970's**

Land use in 1880's	Land use in 1970's						
	Paddy	Upland field	Forest	Grass, bush	Urban area	Water, mash	Total
Paddy	71.9	5.9	10.1	0.7	8.9	2.5	100.0
Upland field, orchard	22.4	41.5	15.8	0.7	16.6	2.6	100.0
Forest	8.3	21.3	55.9	1.4	12.6	0.6	100.0
Grass, bush	5.5	21.9	61.3	2.1	8.4	0.8	100.0
Village, road	21.7	15.9	17.2	0.6	39.7	4.9	100.0
Water, mash	11.0	0.9	2.3	0.8	8.8	76.2	100.0





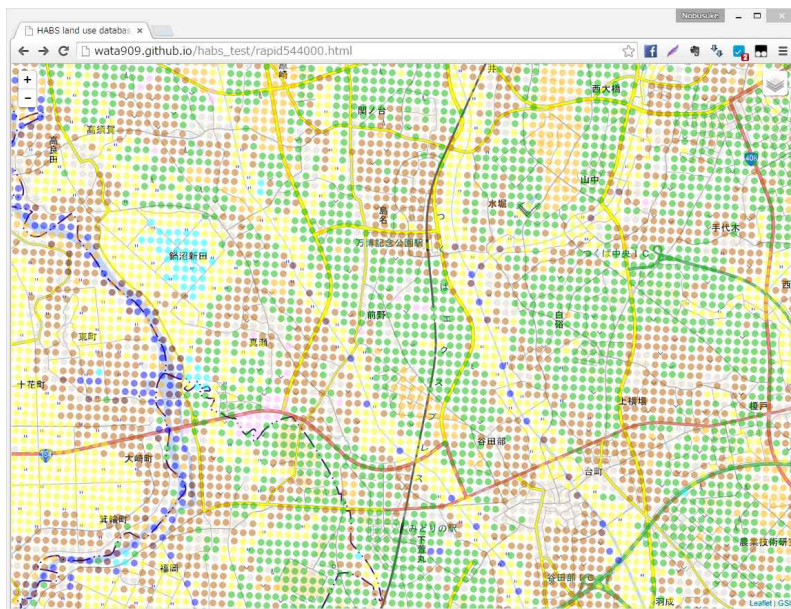
**Figure 5. Land use maps in 1880's and 1970's**

#### **4. Dissemination data as Open Data**

To examine an effective methods for disseminating data, a subset of the constructed database had been published. For the mobile device, point data of the Boso Peninsula were converted to 100m grid polygon data as mbtiles format. RSM raster data were also provided as mbtiles.

For the Web and GIS analysis, we had been converted database to GeoJSON and uploaded to GitHub. The license of the uploaded data is Creative Commons BY 2.1, Japan. Currently, 27 map grids were uploaded. GeoJSON data can be displayed in GitHub page by default. But, all of point data were displayed same legend. Therefore, a tentative data browsing site was constructed with Leaflet (Figure 6). In this site, it is possible to choice present topographic map/RSM raster data as a base layers and display the point type land use data in the 1880's. By overlaying the present and passed information, it makes easier to recognize local land use change.

In GitHub, a user can check change history of data and also report error of data. We would like to make a communication with user using these function and develop a participatory accuracy assessment system, in the future works.



**Figure 6. Overlay point based land use data and present topography map**

## 5. Conclusion

In this paper, we described about development of the land use database derived from RMS of the Kanto region, Japan in the 1880's. We developed land use database as 100m grid point and about 90% of database has been inputted. The accuracy of point data are reliable for examining land use change and we conducted land use change analysis of east part of the Kanto region. Then, a subset of the constructed database had been published for examining an effective methods for disseminating the database.

In previous study, we published RMS raster data as Web-GIS and also provided tile map data. These data promoted utilization of RMS not only for academic use, but also for an individual interest. We hope that this database also contributes for dissemination of RSM utilization not only for academic research, but also for business, government, and public interest.

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